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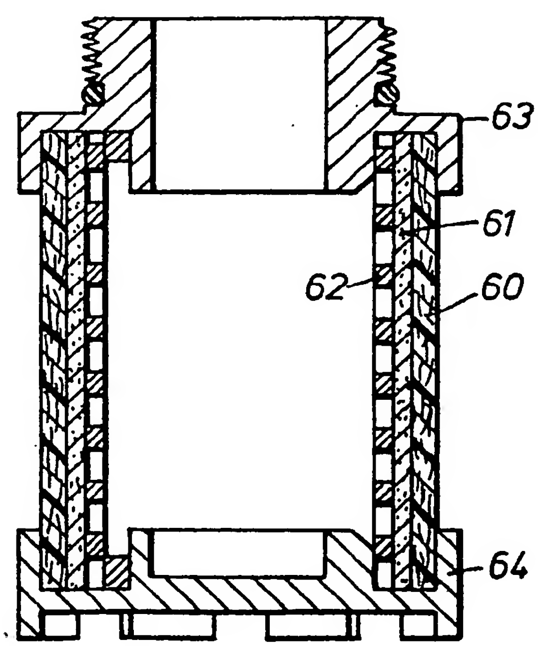
(54) Coalescing filter element

(57) A coalescing filter element comprises a tubular anti re-entrainment barrier 60, one surface of which is directly coated with borosilicate microfibres 61 free of any resin impregnation, the coating being of a thickness sufficient to filter the gas passing through it and to coalesce any liquid droplets therein. In manufacture, the preformed barrier is supported by a perforated mould and a slurry of microfibres is forced to flow through the barrier to deposit the microfibres thereon. The microfibre layer is formed on the upstream side of the barrier, which may be its internal or external side, and further perforate supports such as 62 may be provided on one or both sides, possibly separated by a layer of scrim from the microfibre layer.

Fig. 7.



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

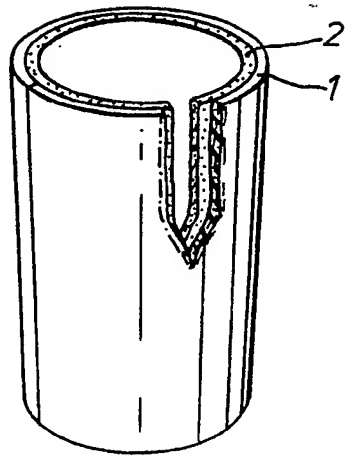

Fig. 1.

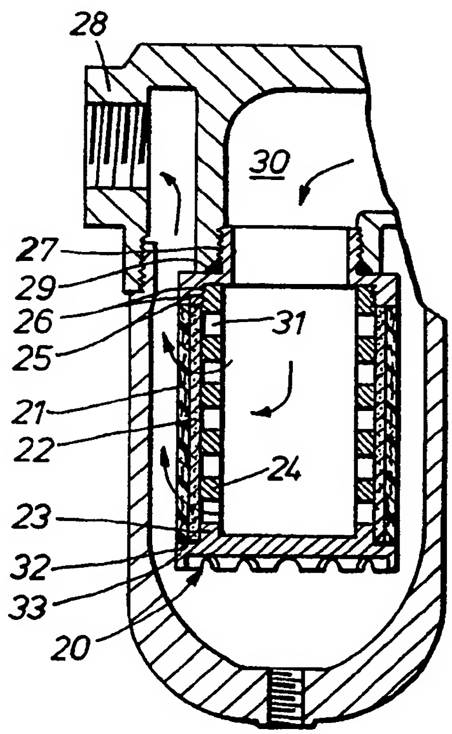

Fig. 4.

Fig. 2.

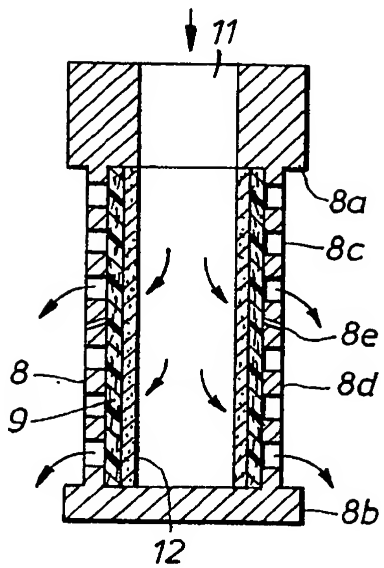

Fig. 3.

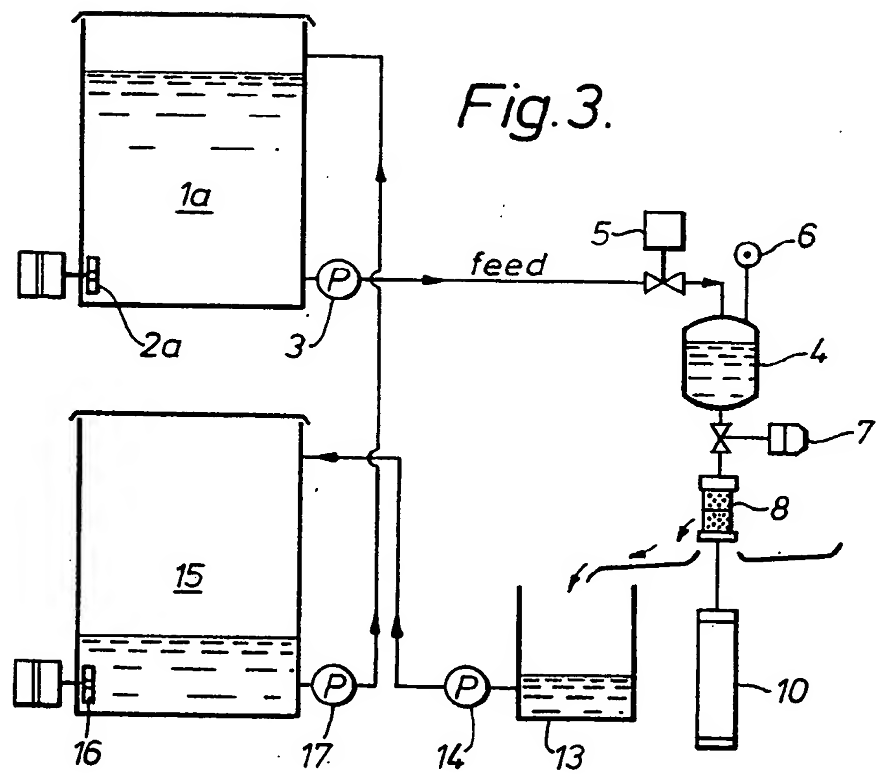

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Fig. 5.

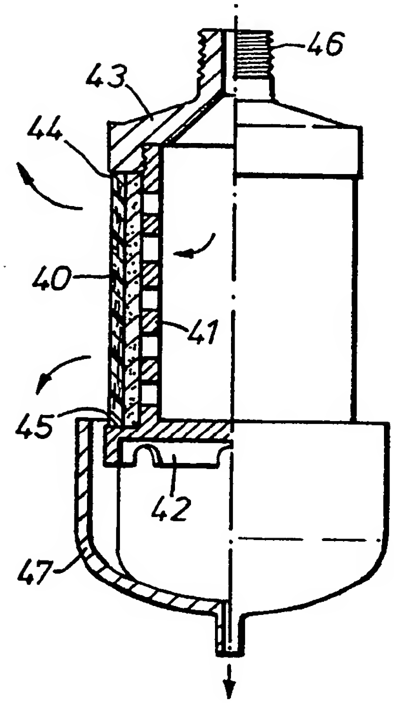


Fig. 7.

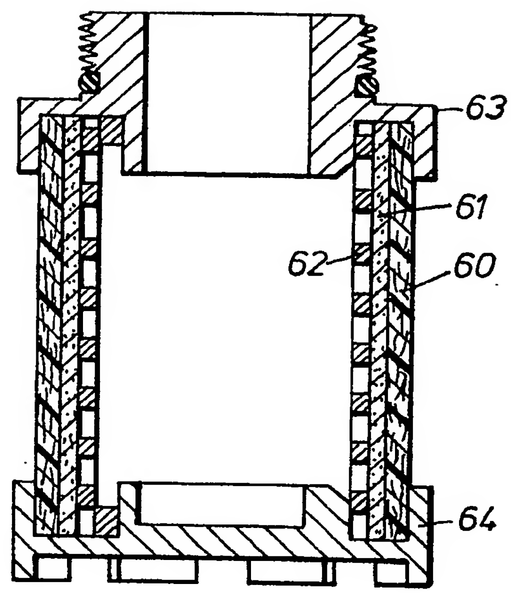
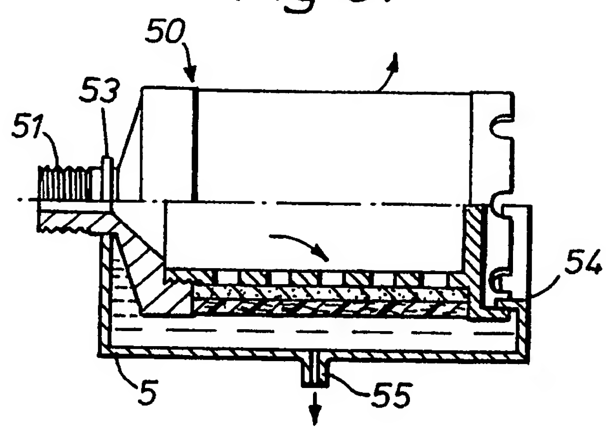


Fig. 6.



SPECIFICATION

Coalescing filter element, method of making such an element and a filter incorporating such an element

This invention relates to a coalescing filter element, to a method of manufacturing a coalescing filter element and to a filter incorporating such filter element.

Filters for coalescing liquid aerosol from a compressed gas flow are now in common use. Perhaps the commonest application is in the coalescing of oil/water aerosol from compressed air flow provided by a compressor. Many types of filter are known for this purpose, and probably the commonest group relies on a cylindrical filter element through which the compressed gas flows either from inside to outside the element or from outside to inside of the element. In the former type compressed air to be filtered is fed axially into the filter from one end thereof, passes through the filter and is discharged to the atmosphere through the radially outer surface thereof. In the latter type compressed air is drawn through the filter from the outer surface and filtered air is discharged axially from one end of the interior of the filter.

The filter medium that is commonly used in this type of filter is made up of a non-woven mass of borosilicate microfibre, commonly impregnated with resin to increase the strength of the resulting mass. On at least the downstream side of the tube of filter material this tube is supported by a porous sleeve, and it may also be similarly supported on the upstream surface to prevent disruption of the filter layer should back pressure occur in the system. Support for the filter layer has been proposed in a number of different ways. For example, support may be from perforated metal sleeves, may be from a sleeve of woven synthetic fabric, for example nylon or polyester, or may be from a sleeve of further filter material having greater strength than the borosilicate microfibre sleeve. Many different permutations of such elements have been proposed.

In the coalescing filtration of a liquid aerosol from a gas flow it is necessary to ensure that the coalesced liquid drains from the filter and is not re-entrained within the filtered gas and carried thereby from the filter. Accordingly, it is common practice for the combination of filter element and its supporting members to be fitted with an anti re-entrainment barrier on the downstream side of the filter element. Anti re-entrainment barriers are typically relatively thick sleeves of high porosity thus providing channels through which coalesced liquid may drain by gravity to drip from the lower part of the barrier. Filtered gas passes through the porous anti re-entrainment barrier quite freely and re-entrainment of filtered liquid is substantially prevented. Commonly the anti re-entrainment barrier is fitted to a unit comprising the microfibre filter material and its support or supports after that unit has been assembled.

The present invention seeks to provide an extremely simple and cheap filter unit that can easily be made into a filter and that avoids disadvantages of prior art filter elements.

According to the invention a coalescing filter element comprises a tubular anti-re-entrainment barrier, one surface of which is directly coated with non-impregnated microfibres to a thickness sufficient to effect filtration.

A method according to the invention of making a coalescing filter element comprises providing a perforated tubular mould, placing a first circumferential surface of a tubular anti re-entrainment barrier adjacent to the mould, causing a resin-free slurry of microfibres to flow through the anti re-entrainment barrier from the second surface to the first surface thereof and so deposit microfibres directly onto the second surface of the anti re-entrainment barrier.

The invention thus provides a coalescing filter element that in its simplest form comprises only two elements, an anti re-entrainment barrier onto one surface of which has been moulded a layer of non-impregnated microfibres.

In a filter designed for flow from inside to outside of the filter element the microfibres will be deposited on the inner surface of the anti re-entrainment barrier. In this case it is found that the anti re-entrainment barrier possesses sufficient strength to withstand the radially outwardly applied pressure due to the gas flow and no further support whatsoever is needed radially externally of the microfibre layer. It is common in filter technology to safeguard against the effects of back pressure in the system and accordingly in this case it is desirable that a perforated, substantially rigid sleeve should lie adjacent to the radially inner surface of the microfibre layer. For certain applications it may be found desirable to provide a similar sleeve adjacent to the outer surface of the anti re-entrainment barrier.

For a filter where the gas flow is intended to be from outside to inside of the filter element the microfibres will be moulded onto the outer surface of the anti re-entrainment barrier. It is unlikely that the anti re-entrainment barrier will have sufficient hoop stress in compression to withstand buckling and accordingly a filter element of this kind will generally incorporate a perforated, substantially rigid sleeve in contact with the inner surface of the anti re-entrainment barrier. A similar sleeve should surround the outer surface of the microfibre layer in order to prevent disruption of this layer should back pressure occur in the system.

The invention is generally applicable to any form of anti re-entrainment barrier and any form of microfibre filter layer. Desirably, however, the anti re-entrainment barrier is made up of a felt-like material composed of fibres ranging in diameter from 5 to 50 microns and the thickness of the barrier is in the range of 1.5 mm to 8 mm. Desirably also the microfibres are borosilicate microfibres ranging in diameter from 0.05 to 10 microns, the thickness of the layer being in the range of from 2 mm to 15 mm.

A coalescing filter in accordance with the invention comprises a coalescing filter element in any of the aforementioned forms, the axial ends of the filter element being in contact with respective end caps at least one of which has a gas flow passage opening into the interior of the element. It is necessary to ensure that the filter is gas-tight in the regions of the axial ends of the filter element and accordingly these ends where they abut the end caps are desirably sealed by a suitable sealant composition. Other sealing systems utilising dip sealing (for example with methane), knife edges, crushing of the filter element material or labyrinthine seal arrangements are also possible.

The invention will be better understood from the following description of specific embodiments thereof, given in conjunction with the accompanying drawings in which:—

Figure 1 is a perspective view of a filter element;

Figure 2 is a cross-section through a mould used in the manufacture of Fig. 1;

Figure 3 is a schematic layout of moulding equipment used in the manufacture of the element of Fig. 1;

Figure 4 shows a first embodiment of filter embodying a filter element according to the invention; and

Figures 5 to 7 show further embodiments of filter incorporating such a filter element.

Referring to Fig. 1 this is a perspective view of a coalescing filter element designed to filter oil/water aerosols from compressed air flowing from inside to outside of the filter element. The element comprises a tubular anti-reentrainment barrier 1 made from a felt-like material of polyester or nylon or a mixture of both, or of polypropylene fibres, the fibres ranging in diameter from 5 to 50 microns. The barrier may be seamless or may be formed from flat sheet joined by any suitable means to form a tube. The inner surface of the barrier is directly coated with a layer 2 of non-impregnated borosilicate microfibres, the microfibres having a diameter in the range of from 0.05 to 10 microns. The thickness of the anti-reentrainment barrier will generally be from 1.5 mm to 8mm and the thickness of the layer of microfibres from 2mm to 15mm. Although the microfibre layer is in itself weak the anti-reentrainment barrier has sufficient hoop strength and axial strength to enable the filter element to be handled in subsequent assembly processes.

Figs. 2 and 3 illustrate one way in which the filter element of Fig. 1 may be manufactured. A mixing tank 1*a* holds a slurry of borosilicate microfibres suspended in water and adjusted to a pH of about 3 in order to assist dispersion of the fibres. The slurry is devoid of resin. The tank includes a motor-driven impeller 2*a* to effect constant stirring of the tank contents in order to assist fibre dispersion and ensure an even concentration of fibres. A pump 3 is connected to an outlet from the tank and transports a measured quantity of slurry into a holding tank 4 when a feed valve 5 is opened. After closure of the feed valve 5 air under pressure is supplied from a source 6 to the holding tank 4 to push slurry from the tank through a valve 7 into the interior of a mould 8.

The mould 8 comprises an upper section 8*a* and a lower section 8*b* the two sections being in axial alignment. The lower section 8*b* is movable towards and away from the section 8*a* by a pneumatic ram 10 and when in its upper position as shown in Fig. 2 wall sections 8*c* and 8*d* respectively of the two parts lie in contact at 8*e*. Each wall section is perforated.

With the mould open by lowering of the part 8*b* a pre-formed anti re-entrainment barrier 9 can be loaded into either mould part so that when the mould is closed the barrier lies radially inwardly of the wall sections 8*c* and 8*d*. As slurry is injected into the mould under pressure through a top opening 11 the anti re-entrainment barrier 9 is forced radially outwardly into intimate contact with the wall sections 8*c* and 8*d*. The liquid from the slurry passes through the material of the anti re-entrainment barrier and through the openings in the wall sections 8*c* and 8*d*. The microfibres in the slurry cannot pass through the anti re-entrainment barrier and are thus trapped on the inner surface thereof to build up a layer of microfibre filter material that is in direct contact with the inner surface of the anti re-entrainment barrier. Liquid passing through the wall sections 8*c* and 8*d* is collected in a scavenge tank 13 and pumped by a pump 14 to a holding tank 15. The holding tank 15 is used to mix a further batch of slurry, mixing being effected by a motor-driven impeller 16. Tank 1*a* can be reloaded from holding tank 15 by a pump 17.

Once the measured batch of slurry has been injected into the mould 11 and the liquid has passed through the wall sections 8*c* and 8*d* the desired weight and thickness of microfibres have been deposited on the inner wall of the anti re-entrainment barrier. A supply of compressed air follows the slurry batch into the mould and has the effect of partially drying the moulded assembly. After this par-

tial drying the mould is opened and the resulting structure of anti re-entrainment barrier with moulded microfibre layer is dried in an oven to form the finished element.

Fig. 4 illustrates one way in which the filter element of Fig. 1 can be used in a filter shown generally as 20. The filter comprises the filter element of Fig. 1 made up of an anti re-entrainment barrier 21 onto the inner surface of which has been moulded a layer 22 of borosilicate microfibre. This structure is fitted over a perforated cylinder 24 formed integrally with a bottom cap 23 of the filter and made from substantially rigid material. A top cap 25 of the filter is connected to the cylinder 24 by a screw thread 26. The top cap has a threaded spigot 27 by way of which the filter can be secured into a filter housing 28, a seal 29 being provided between the filter housing and the filter. Sealing between the axial ends of the filter element and the surfaces of the top and bottom caps which the filter element abuts, for example the region 32 at the bottom of the filter, are sealed by a suitable sealing compound 33.

In use, a gas supply to be filtered is supplied to the filter housing inlet 30 and from there passes into the interior of the filter 20. The gas passes through the apertures 31 in the cylinder 24 and liquid aerosol in the gas is coalesced by the microfibre filter layer 22. The coalesced liquids drain down under gravity by way of the anti re-entrainment barrier 21 to collect in the base of the filter housing from where they may be drained as required.

Fig. 5 shows a further form of filter utilising the filter element of Fig. 1. As with the embodiment of Fig. 4 the filter element 40 surrounds a perforated cylinder 41 integral with a bottom cap 42. A top cap 43 is screw threaded onto the upper end of the cylinder 41 and a sealing compound is applied at 44 and 45 where the end caps abut the filter element. The top cap 43 has an externally threaded spigot 46. A filter of this type can readily be used as an air silencer/oil reclassifier in pneumatic systems where oil can contaminate air being exhausted from valves, pistons and other components. The spigot 46 is a suitable pipe connection designed to fit directly into the port of a pneumatic valve or other device so that when oily air is vented from the device it passes into the filter and is exhausted through the filter element. The microfibre filter layer coalesces the oil which drains down the anti re-entrainment barrier and the filter also has the effect of reducing exhaust noise. The filtered air passes direct to atmosphere. The filter as shown in Fig. 5 is provided with a bowl 47 which may be a fixture on the bottom cap or removably mounted on the bottom cap, the bowl having a drain port from which air and other liquid contaminants collected in the bowl can drain.

Fig. 6 shows a filter 50 similar to that of Fig. 5 and adapted to be connected to a pneumatic device by the threaded spigot 51 with the axis of the filter aligned horizontally rather than vertically. In this case a collecting bowl 52 is supported from the top and bottom end caps at 53 and 54 respectively and extends below the lower part of the filter in order to collect liquids draining from the filter through the anti re-entrainment barrier. The bowl again incorporates a drain port 55.

Fig. 7 shows yet another filter construction in which the filter element of Fig. 1 may be incorporated. The filter element 60 is supported on the inner surface of the microfibre filter layer 61 by a perforated cylinder or a coil spring 62 and the resultant assembly is encapsulated between top and bottom caps 63 and 64 with a suitable sealant compound. The cylinder or spring 62 prevents collapse of the filter element should reverse flow occur through the filter which, as are the filters of 4 and 6 designed for flow from inside to outside of the filter.

In any of the filters shown it will be understood that if required a perforated cylinder or other porous reinforcing sleeve may surround the filter element radially outwardly of the anti re-entrainment barrier. It is also possible in any of these constructions to include a layer of fine porous scrim between the microfibre filter layer and the radially inner cylinder that supports this against reverse flow. Such a scrim will prevent migration of microfibres from the filter layer through the inner support cylinder should a reverse flow situation occur. Clearly, if the perforations in the inner support cylinder are small enough then no scrim will be necessary.

The invention may also be used to provide a filter element destined for a filter where flow is from outside to inside of the element, and in this case the microfibre filter layer will be moulded onto the outer surface of the anti re-entrainment barrier, the mould used in the moulding process being modified accordingly. Filter constructions utilising such a filter element will be apparent to those skilled in the art.

It will also be apparent that filter elements according to the invention may be made by moulding methods other than that particularly described and that they may be incorporated in many different filter constructions.

CLAIMS

1. A coalescing filter element comprising a tubular anti re-entrainment barrier, one surface of which is directly coated with microfibres free of any resin impregnation, the coating being of a thickness sufficient to effect filtration.

2. A coalescing filter element according to claim 1 in which the inner surface of the barrier is the surface coated with the microfibres.

3. A coalescing filter element according to claim 1 or claim 2 in which the barrier is made up of a felt-like material composed of fibres ranging in diameter from 5 to 50 microns.

4. A coalescing filter element according to any one of the preceding claims in which the thickness of the barrier is from 1.5 to 8mm.

5. A coalescing filter element according to any one of the preceding claims in which the microfibres are borosilicate microfibres ranging in diameter from 0.05 to 10 microns.

6. A coalescing filter element according to any one of the preceding claims in which the coating of microfibres is from 2 mm to 15 mm in thickness.

7. A coalescing filter element substantially as herein described with reference to Fig. 1 of the accompanying drawings.

8. A coalescing filter comprising a coalescing filter element according to any one of the preceding claims, end caps in contact with respective ends of the filter element, at least one end cap having a gas flow passage opening into the interior of the element, and means effecting a gas-tight seal between each end cap and the respective end of the filter element.

9. A coalescing filter according to claim 8 in which a perforated substantially rigid sleeve lies adjacent to the radially inner surface of the filter element.

10. A coalescing filter according to claim 9 in which the radially inner part of the filter element is the microfibre layer, and a layer of fine porous material lies between the microfibre layer and the substantially rigid sleeve.

11. A coalescing filter according to any one of claims 8 to 10 in which a perforated, substantially rigid sleeve lies adjacent to the radially outer surface of the filter element.

12. A coalescing filter substantially as herein described with reference to any one of Figs. 4 to 7 of the accompanying drawings.

13. A method of making a coalescing filter element comprising providing a perforated tubular mould, placing a first circumferential surface of a tubular anti re-entrainment barrier adjacent to a surface of the mould, causing a resin-free slurry of microfibres to flow through the anti re-entrainment barrier from the second circumferential surface to the first circumferential surface and so deposit a layer of microfibres directly onto the second surface of the anti re-entrainment barrier in thickness sufficient to effect filtration, and drying the deposited layer.

14. A method according to claim 13 in which the anti re-entrainment barrier is placed radially within the mould and the flow of slurry is from the inner to the outer surface of the anti re-entrainment barrier to deposit the microfibre layer on the inner surface of the barrier.

15. A method according to claim 13 or claim 14 in which the mould is split into two axial sections and in sequence the mould is opened by moving the sections axially apart, inserting the anti re-entrainment barrier into one of the sections, moving the sections axially together to enclose the barrier, causing the slurry to flow and deposit the microfibre layer, opening the mould and removing the coalescing filter element.

16. A method of making a coalescing filter element, substantially as herein described with reference to Figs. 2 and 3 of the accompanying drawings.

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